Agricultural Impacts on the Fishes of the Eel River, Indiana

James R. Gammon and Clifford W. Gammon
Department of Biological Sciences
DePauw University,
Greencastle, Indiana 46135

Abstract
The Eel River of northern Indiana is a major tributary of the Wabash River. It is approximately 177 km (110 mi) in length with an average rate of descent of 0.457 m/km (2.41 ft/mi). Approximately 79% of its 210,800 ha (814 m^2) drainage basin is devoted to row-crop agriculture. The fish communities and habitat were studied during the summer of 1990. Fish were collected from 25 sites located throughout the Eel River and some of its tributaries. A 3/16 inch mesh, 30 ft by 4 ft seine was effective in collecting small fish including darters. Backpack electrofishing was also used at most stations on two separate dates. Historic records of the fish communities were examined and, when possible, converted into Indexes of Biotic Integrity values so that changes over time could be estimated. Habitat evaluation included a mainstem reconnaisance, a habitat survey (HEP) conducted at all collecting stations, and a synoptic turbidity survey on July 16 and 17, 1990. Estimates of the amount of woodland were made from conventional analysis of enlarged infrared photographs. Analyses of existing suspended sediment data were used to evaluate possible impacts of nonpoint-source influence from agricultural fields as well as historic records of fish kills and chemical spills within the Eel River watershed. The 1990 fish community was generally better than the community found in 1982. However, this improvement is probably temporary and the result of a series of recent years when both river discharge and suspended sediment concentrations were lower than normal. From a longer time perspective the fish community is degraded, with many species which were common 50 years ago now either absent or very severely reduced. Rainbow darter, orangethroat darter, bluebreast darter, and stonecat were not collected at all. Sculpin, greenside darter, blackside darter, silver shiner, rosyface shiner, longear sunfish, and smallmouth bass were very restricted in distribution.

Key Words: non-point source, habitat, suspended sediment, fish community, Indiana

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Introduction
In 1982 populations of smallmouth bass (Micropterus dolomieui) were found to be virtually lacking by Braun and Robertson (1982) who collected from the same sites as Taylor (1972). Exerting roughly equivalent effort and similar methods, Taylor (1972) collected 98 smallmouth bass while Braun and Robertson (1982) found only 3. During the 1980's smallmouth bass populations in the lower part of the Eel River were augmented by stocking fin-clipped fingerlings (5130 fish on 10-28-83; 5000 on 9-17-85; and 6960 on 4-17-86). A limited number of stations were more intensively sampled and additional tributaries were also investigated.

The current study was planned to provide information about the fish communities at all of Taylor's sites and a few additional sites. It included an evaluation of instream and near-stream habitat from the standpoint of agricultural nonpoint sources of pollution and their possible influence on those fish communities. This report is a condensation and extension of a larger report to the Indiana Department of Environmental Management (Gammon and Gammon 1990).

The Study Area
The Eel River is a major tributary of the Wabash River in northern Indiana. Originating in northwest Allen county near Ft. Wayne, it flows southwest for approximately 177 km (110 miles) through Kosciusko, Whitley, Wabash and Miami counties into the Wabash

River at Logansport in Cass county. Its rate of descent is approximately 0.457 m/km (2.41 ft/mile) with a lower rate in the upper third and a slightly higher rate in the lower 20 km.

This area originally contained glacial lakes and swampy wetlands, but it was extensively ditched and drained prior to 1900 for agricultural use. Approximately 79% of its 2,148 km2 (814 m2) drainage basin area (Hoggatt 1975) is devoted to rowcrop agriculture, primarily corn and soybeans. Most of the smaller tributaries and the upper river have been channelized to facilitate drainage. Low mill dams have been constructed at various locations, many of which are currently in a state of disrepair except in Logansport. That dam severely restricted the movement of Wabash River fishes into the Eel River and facilitated evaluations of impacts.

Materials and Methods

The study included a) a reconnaisance float trip of the entire river, b) sampling each station twice by electrofishing, c) sampling most of these same stations once by seining, and d) a habitat survey (HEP) at each station. Secchi transparency and temperature were routinely measured on each occasion. In addition, synoptic short-term profiles of turbidity, temperature, and dissolved oxygen concentration were determined on three separate dates.

Single stations were located on lower Twelve Mile, Paw Paw, Squirrel, Beargrass, and Sugar Creeks, and also upstream and downstream of Columbia City on Blue River. The remaining 16 stations were located on the mainstem of the Eel River. A few mainstem stations (Taylor's 2B, 2, and 3) and Squirrel Creek were not seined because of inappropriate seining habitat.

Seining was conducted with a 30-foot by 4-foot seine having 3/16 inch mesh weighed down by a heavy steel chain tied to the bottom. This method was very effective at capturing darters and minnows. Three seining passes along 20 meters of shoreline constituted each seine sample.

Electrofishing utilized a Safari Bushman 300 backpack shocker carried in a canoe or while wading, depending on place and depth. Each electrofishing sample was about 20 minutes in duration along approximately 400 meters of shoreline. This method was effective in capturing larger fish such as redhorse and suckers and species which prefer nearshore cover such as sunfish and bass.

All captured fish were identified to species, weighed and measured, then released back into the river. Those fish not easily identified in the field were preserved in formalin and returned to the laboratory for identification (Trautman 1981).

Fish data were analyzed using the Iwb and the IBI. The 1990 Iwb values were based upon the average of two electrofishing catches at each station. The rationale of this community parameter is presented by Gammon (1980), who recommended multiple collections at each site.

The Iwb was calculated as:

$$Iwb = 0.5 \ln N + 0.5 \ln W + Div.no. + Div.wt.$$

Where, N = number of fish captured per km; W = weight in kg of fish captured per km; Div.no. = Shannon diversity based on numbers; Div.wt. = Shannon diversity based on weight.

The IBI methodology has been thoroughly discussed by Karr (1981 and 1987), Karr et al. (1986 and 1987), and Angermeier and Karr (1986). Regional applications are summarized by Miller et al. (1988).

Table 1. Scoring criteria used to determine IBI for Eel River fish collections.

Metric	1(worst)	Score 3	5(best)
Fish species (total)	0-9	10-19	≥20
Darter species	0-1	2-3	≥4
Sunfish Species	0-1	2-3	≥4
Sucker Species	0-1	2-3	≥4
Intolerant Species	0-1	2-3	≥4
No. Individuals	0-100	101-200	≥201
Percent individuals as:			
Green sunfish	11-100	6-10	0-5
Omnivores	45-100	21-44	0-20
Insect. cyprinids	0-20	21-44	45-100
Top carnivores	0-2	3-10	≥11
Hybrids	4-10	2-3	0-1
Diseased	6-10	2-5	0-1

Table 2. Habitat assessment scoring criteria (HEP).

Parameter	Condition Excellent	Good	Fair	Poor
PRIMARY INFLUENCE				
Substrate and Instream Cover				
1. Substrate/cover	16-20	11-15	6-10	0-5
2. Embeddedness	16-20	11-15	6-10	0-5
3. Water velocity	16-20	11-15	6-10	0-5
SECONDARY INFLUENCE				
Channel Morphology				
4. Channel Alter	12-15	8-11	4-7	0-3
5. Scour/Deposition	12-15	8-11	4-7	0-3
6. Pool/Riffle Ratio	12-15	8-11	4-7	0-3
TERTIARY INFLUENCE				
Riparian and Bank Structure				
7. Bank stability	9-10	6-8	3-5	0-2
8. Bank vegetation	9-10	6-8	3-5	0-2
9. Bank cover	9-10	6-8	3-5	0-2

The original criteria for determining IBI (Karr, et. al., 1987) were modified slightly for the Eel River (Table 1). The scaled metrics are those used in studies of the Sugar Creek system (Gammon et al. 1990a) and an agricultural analysis of several streams in west-central Indiana (Gammon et al. 1990b). They differ in some details from the criteria used in other studies. The 1990 IBI values were based upon the combined catches from electrofishing and seining. The IBIs calculated on data from earlier Eel River studies may be influenced to an unknown degree by the somewhat different methodologies used to collect fish. Taylor (1972) used a combination of electrofishing and rotenone, while Braun and Robertson (1982) used more intensive electrofishing. We have elected to use the same criteria regardless of stream order.

Habitat was quantitatively evaluated at each mainstem collecting site, except for the most downstream site near the Logansport dam and Taylor's site 1, using a habitat evaluation procedure (HEP; Plafkin et al. 1989) adapted from Platts et al. (1987). HEP quantifies 9 habitat characteristics summarized in Table 2. The total score for each site was based upon data from 10 transects at each site spaced 25, 50, or 100 feet apart.

In addition, several other physical measurements were taken whenever fish collections were made during special longitudinal surveys. Stream turbidity was measured with a secchi disc or a Minispec20 nephelometer. Water temperature and dissolved oxygen were measured using a YSI meter. Water velocity was measured with a Gurley pygmy meter. ALI distances were measured optically using a Leitz rangefinder.

Estimates of the amount of woodland were based on conventional analyses of enlarged LandSat infrared photographs taken on May 2, 1981. These were obtained from the U.S.

Geological Survey (ESIC), EROS Data Center, Sioux Falls, SD.

The drainage area perimeter was determined using topographic maps of tributaries. This scaled map was superimposed over the infrared photographs on a light table. Plots of land with permanent tree cover were outlined on the topographic map.

Using a light table, the marked topographic map was traced onto a fine grid. Individual grids with more than 50% woodland was calculated. Land use in a few tributaries was not determined because of insufficient coverage of LandSat infrared photographs.

Results

A total of 6,635 fish comprising 46 species were captured by electrofishing and seining. Forty species and 4154 individuals (63%) were taken by seining alone. Electrofishing catches also yielded 40 species, but only 2481 individuals or 37% of the total.

Bluntnose minnow (Pimephales notatus) was very common comprising 40.9% of the total number seined, while sand shiner (Notropis stramineus), spotfin shiner (N. spilopterus), striped shiner (N. chrysocephalus), silverjaw minnow (Ericymba buccata), and creek chub (Semotilus atromaculatus) together contributed another 37%.

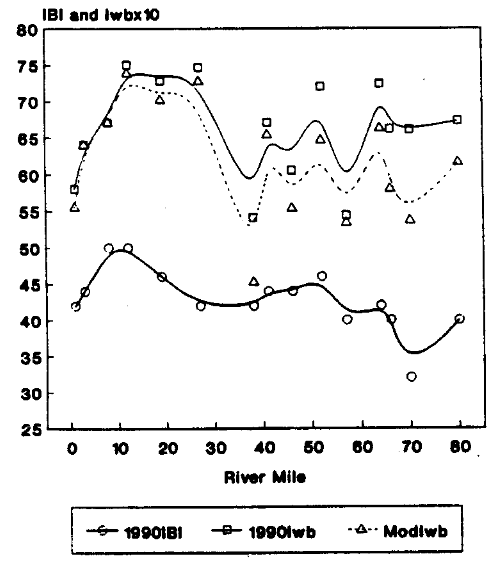
The electrofishing catch was more evenly distributed with common shiner (N. cornutus) and white sucker (Catostomus commersoni) each contributing about 15% to the catch. Substantial numbers of the following were also collected: creek chub (9.3%), bluntnose minnow (9%), rock bass (Ambloplites rupestris; 7.4%), and northern hog sucker (Hypentilium nigricans; 7.1%).

Smallmouth bass (Micropterus dolomeiui) adults and subadults were mostly found in the lower 50 miles of the Eel River and only in Paw Paw and Twelve Mile Creeks. Catch rates were higher in the lower 30 miles of river and attenuated from RM 30 to RM 51.7. Three of 12 smallmouth bass 250 mm and longer were fin clipped, indicating that they were stocked fish. Two of these were collected by electrofishing at RM 37.8(1) near Roann and the other at RM 27.3(6B) near Chili. Young-of-the-year smallmouth bass were taken only in the extreme lower part of the Eel River and in Paw Paw and Twelve Mile Creeks.

Largemouth bass (M. salmoides) formed a minor component of the catch. Fair numbers of small spotted bass (M. punctulatus) were scattered throughout the mainstem Eel and in Paw Paw and Twelve Mile Creeks. This species had not been present since they could easily have been misidentified as small largemouth bass. Spotted bass young-of-the-year were found even in the otherwise poorer habitat of the upper 30 miles above South Whitley. This species has been shown to be tolerant of high turbidity and sedimentation (Gammon 1970).

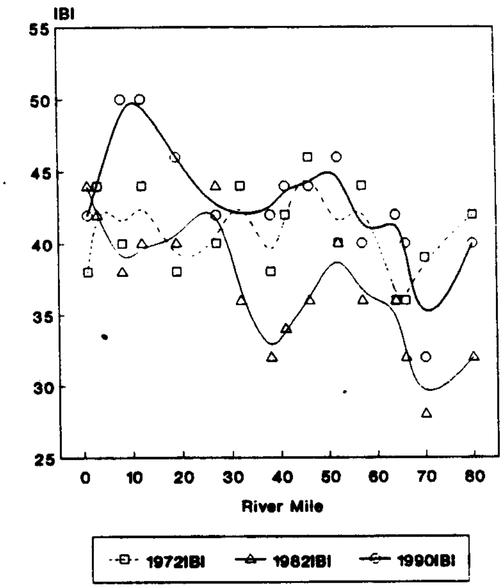
Rock bass was taken at all stations except Squirrel Creek. Longear sunfish (Lepomis megalotis) were most common at the upper mainstem stations and in the Blue River and were sporadic in the lower river. Green sunfish (L. cyanellus) also occurred at most sites, but was more abundant in the upper mainstem and in the Blue River. Substantial numbers of bluegill (L. macrochirus) were also taken more regularly in the upper mainstem Eel from RM 63.5 to RM 80.

The most abundant catostomid was white sucker with greatest numbers in the upper mainstem from RM 63.5 to RM 80 and in the Blue River, Sugar Creek, and Beargrass Creek. They were uncommon in the lower 60 miles of the mainstem. Northern hogsucker was widely distributed throughout the mainstem and most tributaries. Spotted sucker (Minytrema melanops) was found in good numbers only in the pool above the Logansport dam.



IBI based upon Sugar Creek criteria and includes seining data.
Mod. Iwb deletes 'tolerant' species

Fig. 1. IBI, Iwb, and modified Iwb values for 1990 Eel River fish communities.



Based upon Sugar Creek criteria.

Fig. 2. IBI profiles of mainstem Eel River fish communities for 1972, 1982, and 1990.

Golden redhorse (Moxostoma erythrurum) was the most common of the three redhorse species, but it was not all that abundant. It was absent between RM 56.5-80, as well as, from all tributaries including Blue River. Black redhorse (Moxostoma duquesnei) was almost as common as golden redhorse, but was mostly restricted to the lower 30 miles of the mainstem. Greater redhorse (Moxostoma valenciennesi) is a rare species throughout Indiana and most of its range, but a healthy population thrives in the Eel River system. It was particularly abundant in the lower 20 miles of river, but was also found in Paw Paw and Squirrel Creeks.

The distribution of smaller species of minnows and darters is best illustrated by the seining catches. Bluntnose minnow (Pimephales notatus) was the dominant species, occurring throughout the mainstem and tributaries. Common shiner was even more frequently encountered by electrofishing and was also widely distributed throughout the Eel River system.

Spotfin shiner and sand shiner mostly occurred in the lower 50 miles of the mainstem. Creek chub was common only in the tributaries. Redfin shiner (Notropis umbratilus) and rosyface shiner (Notropis rubellus) were most common in the lower river, but also occurred in Sugar and Twelve Mile Creeks. River chub (Nocomis micropogon) was regularly taken by seine and electrofishing mostly downriver from RM 65. A few bigeye chub (Hybopsis amblops) were also present in the lower river.

Among the darters, only johnny darter (Etheostoma nigrum) was common and widespread. Blackside darter (Percina maculata), greenside darter (E. blennioides) and eastern sand darter (Ammocrypta pellucida) were found only in the lower river. Dusky darter (P. sciera) was taken only from upper Eel River (RM 88.0) and Beargrass Creek.

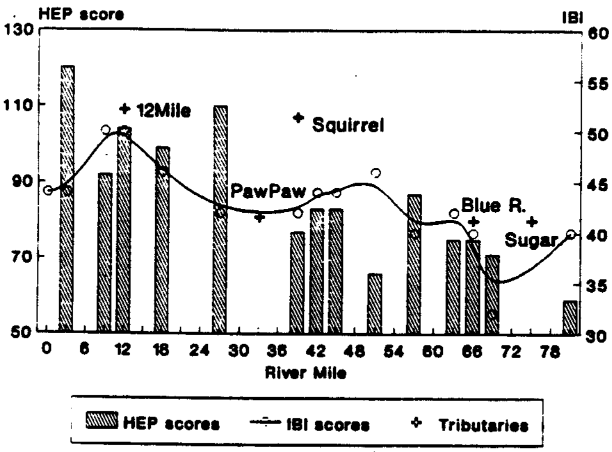


Fig. 3. IBI and HEP values for the mainstem Eel River and tributaries.

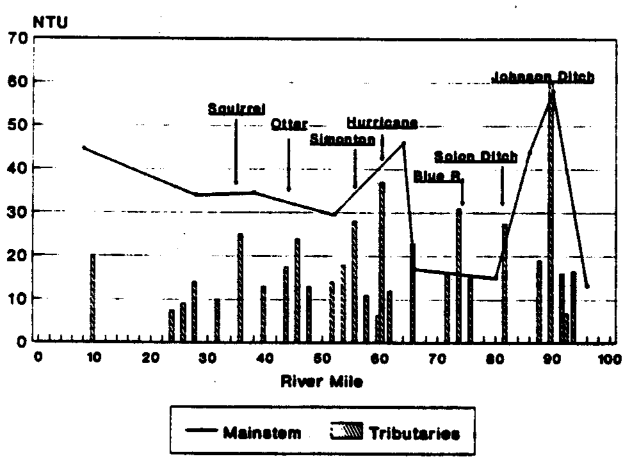


Fig. 4. Turbidity (NTU) for the mainstem Eel River and its tributaries on July 16 and 17, 1990.

Fantail darter (E. flabellare) was collected only at RM 63.5). Mottled sculpin (Cottus bairdi) was taken only at RM 56.5 and RM 63.5).

Important community index values are summarized in Table 3. IBI values were also calculated on less extensive data sets provided by Braun et al. 1984, 1986) on five collections of fish from each of three stations; 2B (RM 3.3), 3B (RM 8.3) and 3 (RM 46.4) during the years 1984 and 1985. The mean IBI values at stations 2B, 3B, and 3 were 39.6, 42.0, and 43.6 in 1984 and 43.2, 41.2, and 42.9 in 1985, respectively.

The IBI and Iwb profiles for the Eel River mainstem are shown in Figure 1. An additional modified Iwb is also shown, wherein four tolerant species were deleted prior to calculation, carp, bluntnose minnow, creek chub, and green sunfish.

All three profiles indicate somewhat depressed fish communities in the lower river, probably because of the ponding effect of the dam, followed by relatively good communities from RM 8 to RM 25. From RM 30 to RM 80 there is considerable variation from place to place, but the communities are generally depressed, especially at RM 70.

In Figure 2, the 1990 IBI profile is repeated and compared to IBI profiles based on Taylor's (1972) and Braun et al.'s (1982) series of collections. The 1990 fish communites are clearly much better than they were in 1982. However, both profiles indicate better communities in the lower river than in the upper river. In 1972 there was less difference in the lower mainstem but equal variation between stations.

Habitat Evaluation

Habitat scores were generally lower in the upper part of the watershed and higher

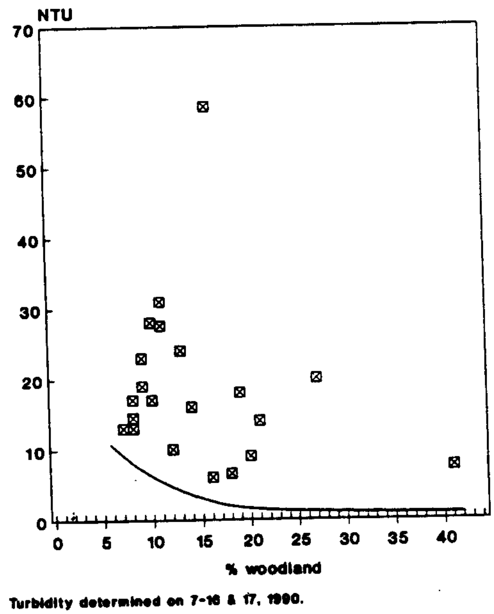


Figure 5. Turbidity (NTU) of Eel River tributaries in relation to percent woodland in their drainage basins.

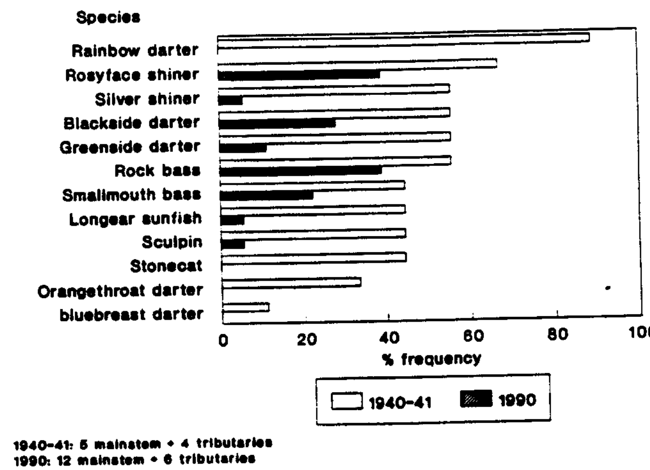


Figure 6. Frequency of occurrence of some species collected by seining in 1990 compared to 1940-41.

downstream. Upstream from South Whitley, habitat features were uniformly low in quality and homogeneous because of past channelization and recent deforestation of both banks. Habitat scores of tributaries were generally higher than the mainstem reaches into which they flowed (Figure 3). An excpetion was Paw Paw Creek which was somewhat lower.

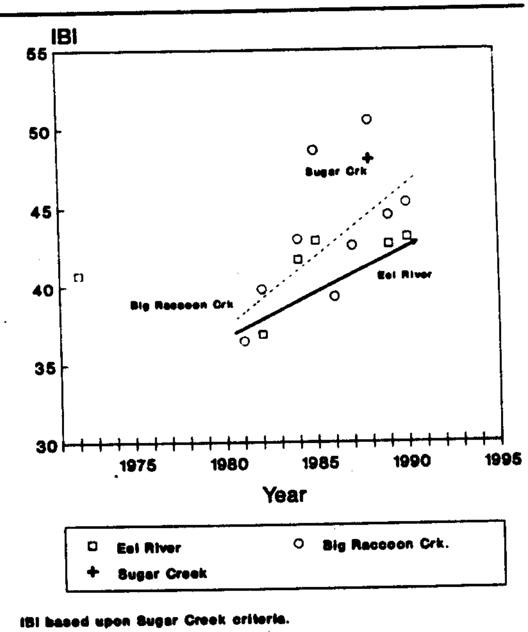


Figure 7. Changes in the IBI values for the Eel River compared to Big Raccoon Creek and Sugar Creek.

Turbidity and Landuses

Turbidity determination during the synoptic surveys on July 16-17, 1990 are portrayed graphically in Figure 4. Scattered showers fell throughout northern Indiana during the week previous to the turbidity determinations. It is not known to what extent these results may be affected by differential rainfall. Tributaries which were disttinctly more turbid than others included Squirrel Creek, Otter Creek, Simonton Creek, Hurricane Creek, Blue River, Solon Ditch, and Johnson Ditch. A bridge was under construction in the Simonton watershed, but

Table 3. Fish community indicies for Eel River stations.

Station Taylor	Station RM	1990 Iwb	No. Spec. elec. 1972	No. Spec. elec. 1982	No. Spec. elec. 1990	IBI 1972	IBI 1982	IBI 1990
1B	1.0	5.8	12	13'	15	38	44	44
2B	3.3	6.4	14	14	14	44	42	44
3B	8.3	6.7	10	11	12	40	38	50
4B	12.0	7.5	17	14	17	44	40	50
5B	19.0	5.3	14	17	18	38	40	46
6B	27.3	7.5	11	12	16	40	44	42
7B	32.0	5.4	17	10	--	44	36	--
1	37.8	6.7	14	8	10	38	32	42
2	41.4	6.1	18	9	17	42	34	44
3	46.4	7.2	16	11	13	46	36	44
4	51.7	5.4	10	12	16	40	40	46
5	56.5	7.2	18	13	10	44	36	40
6	63.5	6.6	13	8	13	36	36	42
7	66.0	6.6	15	9	13	36	32	40
8	70.3	6.6	12	6	16	39	28	32
11	79.8	6.7	19	9	17	42	32	40
Tributary Stations								
Twelvemile Creek								44
Paw Paw Creek								40
Squirrel Creek								40
Beargrass Creek								40
Sugar Creek								40
Blue River - upstream from Columbia City								40
Blue River - downstream from Columbia City								44

animals were also pastured in the stream and some corn fields extended to stream banks.

The turbidity of mainstem water was high in the upper river mainly because of highly turbid Johnson ditch. The water cleared considerably after passing through two mainstem gravel pits at RM 84 then again became progressively more turbid as it flowed downstream.

During this same period the turbidity gradually increased in the mainstem from the upper river to the lower river, although there were localized sharp increases in turbidity downstream from both Johnson ditch and South Whitley. Earlier in the summer (June 12, 1990) when water levels were higher the turbidity (NTU) was 45 in the lower 60 km (40 mi) of river and between 46-48 in the upper river. In some streams lateral erosion can be a major source of sediment and turbidity, but scoured banks were a very limited component of the lower portions of the Eel River mainstem. However, they were highly evident in the channelized upper portions. The entire upper 50 km (33 mi) of the Eel River has been stripped of its trees and bushes along both banks. During this study the trimmings had been removed from the river and were piled along the shore for burning.

Woodlands were readily determined from the infrared photographs, but other kinds of permanent vegetation such as brushlands, pastures, and winter wheat were indistinguishable from one another. estimates of woodland ranged from only 7.0% in the Beargrass Creek watershed to 40.9% in the Weesaw Creek watershed. There was a greater percentage of landuse in agriculture south of the mainstem and in the upper two-thirds of the Eel River watershed than north of the mainstem and in the lower third. There was an inverse relationship between the percentage of tributary watersheds in woodland and the measured turbidity (Figure 5).

Discussion

The Eel River in 1990 was found to support fairly diverse fish communities throughout most of the watershed, although the upper reaches had depressed populations and reduced numbers of species. Many species of juvenile fish were caught, with larger numbers at stations 1B and Twelve Mile Creek. This is an indication that reproduction for many species was successful during the past couple of years.

Several usually common species which Braun and Robertson (1982) did not collect were found in good numbers in 1990: river chub, bigeye chub, several species of shiners including silver shiner, spotfin shiner, rosyface shiner, redfin shiner, and blackside and johnny darters.

Some species present in 1972 were found only rarely or not at all in 1990. These species included mottled sculpin, blacknose dace, unidentified madtom species, suckermouth minnow, largemouth bass, and carp.

It is difficult to evaluate long-term changes in abundance of any single species of fish because of the different collecting methodologies. The comprehensive study of Gerking (1945) used the seine as the primary collecting gear and our effort in 1990 was comparable. Gerking collected from five mainstem sites and four tributaries. We collected from 12 mainstem sites and six tributaries.

A comparison of percent frequency of occurrence from these studies indicates rather drastic reductions for many species populations of sediment sensitive fish (Figure 6). Rock bass, johnny darter, and eastern sand darter appear to be distributed much as they were 50 years ago. However, many species have suffered drastic declines including rainbow darter (E. caeruleum), orangethroat darter (E. spectabile), and bluebreast darter (E. camurum) which may have been totally eliminated from the river.

Changes over time in populations of clams and mussels parallel those of fish. Henschen (1988) concluded that while the Eel River once supported a diversity of mussel species throughout its length, its currently reduced population is mostly confined to the lower river in Cass and Miami Counties.

Changes in the Fish Community over Time

The IBI offers one way of addressing questions about how the overall fish community has changed over time and how it compares to fish communities in other streams. The mean IBI values for the Eel River mainstem stations declined from 40.7 in 1972 to 36.9 in 1982. This increased substantially to 43.1 in 1990. The IBI values estimated from data of the studies of Braun et al (1984, 1986) and Braun (1990) generally corresponded to improving trend noted in the 1980's.

The overall Eel River fish community appears to have improved rapidly from the degraded community found in 1982.

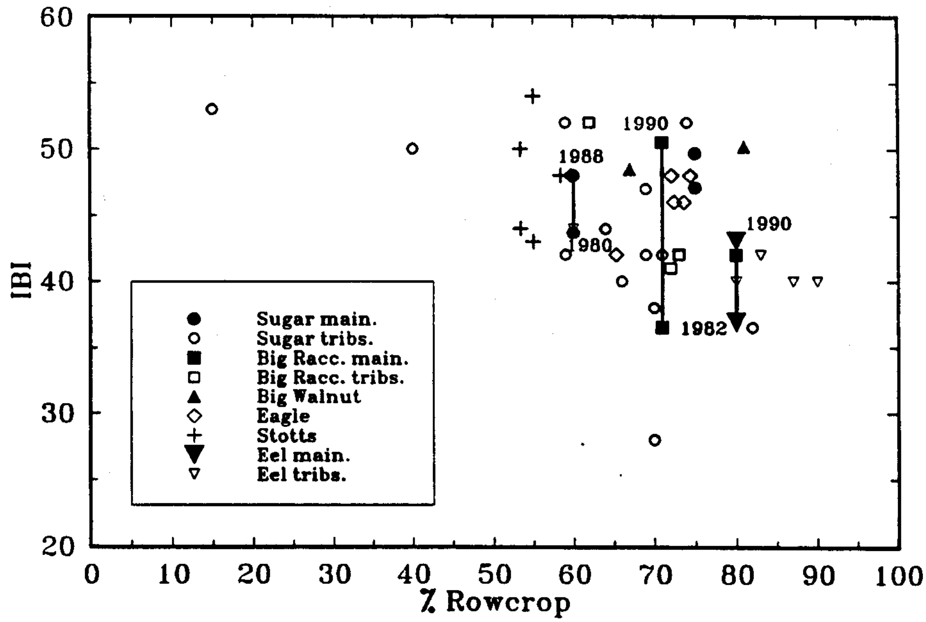


Fig. 8. IBI values of fish communities in Indiana streams primarily influenced by nonpoint source pollution in relation to percent of the watersheds in rowcrop.

IBI values from two other streams are also shown for comparison in Fig. 7 for Sugar Creek (Parke and Montgomery Counties) and Big Raccoon Creek (Putnam County).

We noted the same kind of improvement during the 1980's in Big Raccoon Creek, another stream system influenced primarily by agriculture (Gammon et al. 1990; Gammon 1990). In Big Raccoon Creek the mean IBI was lowest in 1981 (IBI = 36.5) and highest in 1988 (IBI = 50.5). The low IBI values from 1981 through 1984 probably resulted from poor reproduction and survival during unusually high water in the summers of 1979, 1981, and 1982. Darters, sunfish, and bass were virtually absent during those years, but increased significantly by the end of the decade.

The unusually high IBI value found in 1988 was associated with extremely low flows and a prolonged drought. Fish were undoubtedly concentrated and, therefore, much more vulnerable to capture.

The Sugar Creek system has also been examined during the past decade (Gammon and Riggs 1983; Gammon et al. 1990). Estimates from 1979 and 1980 data also indicate lower IBI values at that time than in 1988. This stream is less influenced by agriculture.

All of the data presented by Gammon et al (1990) together with the more recent assessments are summarized in Fig. 8. All three of the stream systems examined over the past decade or so have shown improved fish populations, the extent of the change, indicated by the vertical lines. Big Raccoon Creek changed the most and Sugar Creek the least. The pattern of changes suggests that in watersheds with intensive agriculture, e.g. Eel River, the scope for improvement may be more limited than in watersheds with somewhat less intensive agriculture, e.g. Big Raccoon Creek.

Nevertheless, a series of years with high runoff and increased non-point source pollution can depress fish communities to equally low levels.

Other factors which may modify the recovery of fish populations in the Eel River system include the absence of high quality tributaries to serve as refugia for sensitive species during unfavorable years and the dam blockage at Logansport which reduces recolonization by species from the Wabash River.

The Potential Influence of Habitat and Turbidity

Much of the upper Eel River is characterized by low HEP values, e.g. channelized stream beds, poor riffle/pool development, and a lack of instream structure. In addition, riparian trees have been removed recently from many older previously channelized sections of the river.

The bottom substrate usually included much fine sediment, as indicated by the low embeddedness scores for almost all of the mainstem stations and most tributaries. Turbidity was high for virtually the entire summer. At Roann we saw a layer of mud two centimeters deep on top of a flat boulder after higher water had subsided in a pool.

The lower 48 km (30 mi) of Eel River contained much better habitat than the upstream reaches. Beds of water willow (Dianthera) were mostly limited to the lower 64 km (40 mi) of the mainstem Eel. This section also had fairly good riparian protection and good instream habitat.

Habitat in the tributaries generally scored higher than the mainstem. Twelve Mile Creek, with 26.5% of its watershed in forest, contained the best habitat, followed by Squirrel Creek. The Blue River is approximately the same size as the Eel River where the two streams converge. With only 11% permanent vegetation cover, its turbidity readings were among the highest recorded. Fish from this stream, and Paw Paw Creek, were commonly infected with blackspot disease (Simon 1989).

Potential Negative Effects from Point-Source Pollution

Agricultural point-source pollution in Indiana often occurs because of accidents or careless handling of animal wastes and farm chemicals. Spilled materials, animal wastes applied to fields, and the contents of waste holding lagoons may be flushed into ditches and streams following rain storms. Fish kills reported to the Indiana Department of Environmental Management (IDEM) since 1969 include five incidents on Paw Paw Creek and single kills on Twelve Mile, Pony, Beargrass, and Clear Creeks.

There were 39 additional reports of spilled materials which are not known to have resulted in fish kills, but which may have exerted sublethal damage. Most of the materials were fertilizer and animal wastes, which include wastes generated by chickem, turkey, veal, and swine rearing operations.

All of the known causes of ifsh kills and most of the spills reported within the Eel River watershed are agriculturally based. The actual number of fish kills and spills is unknown, but would certainly far exceed the number of reported cases.

In the decade following passage of the Clean Water Act of 1972, it was estimated that municipal BOD loads decreased by 46% and industrial BOD loads decreased at least 71% (U.S. Environmental Protection Agency, 1982). Most of the communities in the area have improved waste treatment and reduced BOD concentrations by at least 50%. Some previously unsewered communities now have a central treatment system. It is likely that any negative influences from these point sources are masked by the magnitude of non-point source impacts.

Weather and Nonpoint Source Pollution

Unlike point source pollution, nonpoint sources of influence such as occurs from plowed fields are most severe during storm events. The discharge of rivers is roughly proportional to the amount of rainfall, hence, non-point sources are most severe when rainfall is great and river discharge is high. Conversely, non-point sources are reduced during periods of dry weather. Fish populations are negatively affected by non-point sources during the reproductive period and in the months immediately after hatching, spring and summer.

From October 1974 through September 1980 the U.S. Geological Survey Water Resources Division determined daily sediment loads for the Eel River near Logansport (Anonymous 1974 through 1980). Data from the Eel River and rivers throughout Indiana is analyzed and discussed by Crawford and Mansue (1988). They estimated that for the Eel River the mean annual suspended sediment yield was 178 tons/square mile/year and the flow-weighted mean annual suspended sediment concentration was 89 mg/l (median = 53 mg/l). These values are high for the northern moraine/lake portion of Indiana which Crawford and Mansue found to have the lowest sediment yield. Only that part of the Eel River watershed north of the mainstem resides within the moraine area. The portion of the watershed situated south of the mainstem is located in the Tipton Till Plain where both parameters were generally much larger.

Monthly data from May through August for the years 1974 through 1980 was used for regression analysis of suspended solids concentration on discharge. The regression equation obtained was then used to estimate the suspended solids concentration for the months May through August for the years following 1980 (Figure 9). Suspended solids concentrations were highest during May and June when relatively high discharges occurred during half of the years since 1974. "Wet" summers of relatively high suspended solids concentration include the years 1974, 1975, 1980, 1981, 1982, and 1986. "Dry" summers when Eel River water was relatively clear include the period from 1976 through 1979, 1983 through 1985, and 1987 through 1988.

During "dry" summers the effects of point sources of pollution such as from population centers would theoretically increase, but nonpoint source pollution should be less than normal. For streams influenced mostly by NPS the fish communities following a sequence of "dry" summers should improve. The Eel River fish communities did improve somewhat, but less than might have been expected compared to fish communities in Big Raccoon Creek.

The 1990 fish communities may be as good as the Eel River is able to support considering present land use. The summers of 1989 and 1990 were relatively "wet". Therefore, reproductive success and survivorship through the first year of life would be expected to be lower than normal. It is likely that the 1991 fish communities will be poorer than they were in 1990 and the prognosis for improvement in the future is bleak unless changes in land-use are implemented.

Summary

The Eel River is essentially a linear stream. Its drainage basin is long and narrow and its tributaries are generally small first and second order streams. Improving landuse in these tributaries will be necessary in order to improve the mainstem of the Eel River. Thorough surveys of all tributary watersheds should be conducted using both Geographic Information System (GIS) technology and ground study.

Twelve Mile Creek, Paw Paw Creek, and, possibly, Squirrel Creek appear to be less influenced by agriculture than other tributaries. These tributaries may act as refugia for sensitive species during periods of stress and serve as species reservoirs to replenish the mainstem during more benevolent times. They should receive special attention to ensure that: a) the streamside riparian buffer zone is maintained, b) tilled fields do not impinge on the stream itself, c) hogs and cattle are not pastured directly in the streams, d) appropriate forms of conservation tillage are encouraged, e) animal wastes are properly disposed.

Several other tributaries appear to be more environmentally degraded than others. Otter Creek, Simonton Creek, Hurricane Creek, Blue River, Solon Ditch, and Johnson Ditch delivered higher than average sediment loads to the Eel River during the survey of July 16 and 17, 1990. While this survey is only a brief "snapshot" in time, it nevertheless suggests that these streams may have greater than average negative impacts on the Eel River system. They should also receive the same items of attention listed above.

Streams in the upper watershed are referred to and used as drainage ditches. Nevertheless, these streams are permanent "creeks" and should support normal aquatic life. Their rehabilitation could contribute positively toward the improvement of the lower mainstem. The creation of a "green belt" riparian corridor would also contribute toward a greater ecological diversification.

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